"The Demarcation Current of Mammalian Nerve. (Preliminary Communication.) III. The Demarcation Source and 'the Concentration Law.'" By J. S. MACDONALD, B.A., L.R.C.P.E., University College, Liverpool, Research Scholar of the British Medical Association. Communicated by Professor SHERRINGTON, F.R.S. Received October 18, 1900.

Since writing the previous statement the changes of E.M.F. occurring during the early part of the time spent in saline solutions have been studied more in detail, the nerves being removed every five minutes for examination.

As a result of information so acquired, the following statement can be definitely made. Solutions of NaOH, HCl, NaCl, KCl mainly affect the demonstrable value of the demarcation source according to their concentration, and differ intrinsically from one another in their effects upon this source only in minor characteristics.

Each of these electrolytes produces an effect which is best regarded as a variation of the effect of water, and varies with the concentration according to a simple law. The concentration in each case determines whether the initial value of the demonstrable E.M.F. shall be increased, maintained, or diminished.

A study of the comparative effects of various concentrations of the same electrolyte is of particular interest when the nerve is only immersed for a short period (five minutes), presumably because within this period processes of diffusion interfere least with the concentration of electrolytes in the internal parts of the nerve.

The concentration law found to unite the effects of solutions of NaCl, KCl, HCl is comparatively simple, the case of solutions of NaOH being apparently more complex.

If "E" represents the initial value of the E.M.F.,

"E_n" the value after an immersion of 5′ duration in a solution of concentration "n,"

"n" the concentration in gramme-molecules per litre,

then in the special case of solutions of KCl

$$E_n = E \log \frac{1}{n} \quad \text{approximately.}$$

Thus, taking the data from four experiments performed upon 5 cm. pieces of sciatic nerves (cat), determining the available E.M.F. between cross section and longitudinal surface (*a*) immediately upon removal from the recently killed animal, and (*b*) after an immersion of 5′ in a solution of KCl at 17° C.:—

Experiments with Solutions of KCl.

Concentration: Grammes per cent.	Concentration: Gramme-mols. per litre.	E.M.F. recovered, in terms of the initial value E.
7·45	1	$E \times 0{\cdot}10 = E \log 1{\cdot}2$
3·72	$\frac{1}{2}$	$E \times 0{\cdot}34 = E \log 2{\cdot}2$
1·86	$\frac{1}{4}$	$E \times 0{\cdot}60 = E \log 4$
0·93	$\frac{1}{8}$	$E \times 0{\cdot}90 = E \log 8$

The law connecting the effects of solutions of NaCl is not very different, as is shown by examination of the results of the following experiments made before the relation was discovered. The results are in this case none the less remarkable in so far as the concentrations of the solutions used bear no simple proportion to the normal solution of 1 gramme-molecule per litre (5·85 per cent.).

Experiments with solutions of NaCl.

	Concentration: Grammes per cent.	Concentration: Gramme-mols. per litre.	E.M.F. recovered, in terms of E, the initial value.
(1.)	0·45	$\frac{1}{13}$	$E \times 1{\cdot}15 = E \log 14{\cdot}1$
(2.)	0·6	$\frac{1}{9{\cdot}7}$	$E \times 0{\cdot}92 = E \log 8{\cdot}3$
(3.)	0·9	$\frac{1}{6{\cdot}5}$	$E \times 0{\cdot}77 = E \log 5{\cdot}9$
(4.)	3·0	$\frac{1}{1{\cdot}9}$	$E \times 0{\cdot}34 = E \log 2{\cdot}2$
(5.)	6·0	$\frac{1}{0{\cdot}97}$	$E \times 0{\cdot}13 = E \log 1{\cdot}3$

Presuming temporarily the law connecting these results to be "$E_n = E \log \frac{1}{n}$," then the concentration multiplied by the number of which the logarithm is the proportion between the final and initial value of the E.M.F., should equal unity.

Thus

$$(1.)\quad \frac{1}{13} \times 14{\cdot}1 = 1{\cdot}09$$

$$(2.)\quad \frac{1}{9{\cdot}7} \times 8{\cdot}3 = 0{\cdot}85$$

$$(3.)\quad \frac{1}{6{\cdot}5} \times 5{\cdot}9 = 0{\cdot}90$$

$$(4.)\quad \frac{1}{1{\cdot}9} \times 2{\cdot}2 = 1{\cdot}15$$

$$(5.)\quad \frac{1}{0{\cdot}97} \times 1{\cdot}3 = 1{\cdot}34$$

It is obvious that the law as stated approximately represents the truth in the case of NaCl and KCl solutions. In how far the approximation is different in the two cases must be left to the consideration of further and more exact experiments.

That a similar law is true for solutions of HCl is shown by the following experiments. The stock laboratory solution of 0·4 per cent. HCl was diluted twice, &c., to obtain the required variations of concentration.

Experiments with solutions of HCl.

	Concentration. Grammes per cent.	Concentration. Gramme-mols. per litre.	E.M.F. recovered, in terms of E, the initial value.
(1.)	0·2	$\frac{1}{18 \cdot 2}$	$E \times 0 \cdot 31 = E \log 2 \cdot 0$
(2.)	0·1	$\frac{1}{36 \cdot 3}$	$E \times 0 \cdot 60 = E \log 4$
(3.)	0·0250	$\frac{1}{145 \cdot 2}$	$E \times 1 \cdot 21 = E \log 16 \cdot 2$
(4.)	0·0125	$\frac{1}{290 \cdot 4}$	$E \times 1 \cdot 53 = E \log 33 \cdot 9$

In this case presuming the statement of the law to be

$$E_n = E \log \frac{k}{n},$$

then

$$\begin{aligned} \text{in Case (1.)} \quad k &= \frac{1}{18 \cdot 2} \times 2 \cdot 0 = 0 \cdot 11 \\ \text{(2.)} \quad k &= \frac{1}{36 \cdot 3} \times 4 \cdot 0 = 0 \cdot 11 \\ \text{(3.)} \quad k &= \frac{1}{145 \cdot 2} \times 16 \cdot 2 = 0 \cdot 11 \\ \text{(4.)} \quad k &= \frac{1}{290 \cdot 4} \times 33 \cdot 9 = 0 \cdot 11 \end{aligned}$$

The law in this case is $E_n = E \log \frac{0 \cdot 11}{n}$.

It is obvious that in the three cases considered the concentration law is amply expressed as

$$E = k_1 \, . \, E \, . \, \log \frac{k_2}{n},$$

where k_1 and k_2 are constants.

The interest attached to this mode of expressing the law is seen, upon reference to the theory of concentration cells, to be considerable; and the occurrence of the law cannot be otherwise regarded than as a

valuable confirmation of the reality of the assumption made as to the nature of the demarcation source of the nerve.

Taking the simplest expression for the value of the E.M.F. of such a cell, in which there are two solutions of different concentrations N and n of the same electrolyte at the same temperature,

$$E = K \log \frac{N}{n}.$$

If in such a cell the solution of concentration "N" is retained constant, whereas the solution of concentration "n" is given different values, n_1, n_2, n_3......&c.,

$$E_{n_1} = K \log \frac{N}{n_1},$$

and

$$E_{n_1} = E \log \frac{N}{n_1} \times \frac{1}{\log N/n}.$$

If N is constant, and also if N/n the original relation of the two solutions is treated as a constant, we have

$$E_{n_1} = E \,.\, k_1 \,.\, \log \frac{k_2}{n_1},$$

and this is the relation found existing between the value of the demarcation source of the nerve before (E) and after (E_{n_1}) the immersion of the nerve in a solution of concentration n_1.

November 15, 1900.

The LORD LISTER, F.R.C.S., D.C.L., President, in the Chair.

The Right Hon. Sir Ford North, Professor J. Bretland Farmer, Dr. Patrick Manson, and Professor James Walker were admitted into the Society.

A List of the Presents received was laid on the table, and thanks ordered for them.

In pursuance of the Statutes, notice of the ensuing Anniversary Meeting was given from the Chair.

Professor J. D. Everett, Dr. J. H. Gladstone, and Dr. R. H. Scott were by ballot elected Auditors of the Treasurer's accounts on the part of the Society.

The following Papers received during the Recess, and published or